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ORIGINAL ARTICLE

A human source for ELF magnetic perturbations

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ABSTRACT

Current models that frame consciousness in terms of electromagnetic field theory carry implications that have yet to be fully explored. Endogenous weak extremely low frequency (ELF) magnetic fields are generated by ionic charge flow in axons, dendrites and synaptic transmitters. Because neural tissues are transparent to such fields, these provide the basis for the globally unifying qualities required to properly describe consciousness as a field. At the same time, however, an electromagnetic approach predicts partial transmission of this 1–100 nT field, suggesting external interactions similar to the various ELF magnetic perturbations that are linked to homeostatic and endocrine-related physiological effects. It follows that humans may represent an additional, previously unrecognized source of weak (1–10 nT) ambient ELF magnetic fields.

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Introduction

We recently elaborated (Liboff, 2016a) on the hypothesis (Pockett, 2000, 2012) that consciousness is a manifestation of the electromagnetic (EM) field. Contrary to the electric field description, our argument suggests EM consciousness is made possible because of weak low-frequency magnetic fields generated by neuronal, axonal and neurotransmitter charge flows. At any instant, there are enormous numbers of these miniscule current sources capable of generating a net magnetic field even if only a small fraction of these elements exhibits some degree of in-phase cooperativity. Considering the numbers, it is not difficult to argue that such fields can be as great as 100 nT. In this view, the sum total of one's consciousness, including memory, sensory, cognitive and anticipatory components, is completely described in terms of a time-varying EM vector field, a unifying gestalt that is unique to that individual.

The 100 nT fields that we estimate are generated within the brain are in part sufficiently intense to be detected external to the cranium. This implies that individuals nearby, at distances perhaps up to a few meters, can conceivably share some fraction of the original individual's consciousness.

Although this conclusion clearly has interesting ramifications, we are not suggesting that this is some version of mind-reading, telepathy or extrasensory perception. Indeed, it is highly unlikely that external transmission of one's complete conscious field in this

manner is possible. Instead we choose to focus on the much weaker fractions of this putative EM field that may be locally detectable.

The remote reception that we suggest is possible represents a small fraction of the coherent gestalt that constitutes an individual's overall consciousness field. This fraction can be regarded as contributing to a subtle change in the local EM environment external to the brain, a change we choose to refer to as a magnetic *cue*. The term *cue* is used to distinguish its neurological recognition from that which might follow receipt of a complete thought. Thus, although one's thoughts may have an EM basis, we assume that only incoherent portions can be successfully transmitted outside of the brain. Despite not being consciously recognized by the receiving individual, one can anticipate that magnetic cues can nevertheless result in physiological responses similar to those effects that can occur, for example, following increased solar storm activity. In the following we expand on this concept, arguing that humans are subject to one additional source of weak ELF magnetic field perturbation above and beyond that connected to the known sources of the ambient EM burden.

Weak ELF magnetic fields and the brain

An impressive trail of research evidence strengthens the conclusion that neural function is sensitive to low-intensity low-frequency magnetic fields, a fact that seems to have largely escaped the attention of the

neuroscience community. In a key discovery in the 1970s, WR Adey (Adey, 1981; Bawin et al., 1973, 1976; Blackman et al., 1982, 1985) showed conclusively that relatively weak, non-thermal EM fields can affect brain physiology. Subsequent studies indicated that exposure to low-frequency magnetic fields is able to alter basic neural function in rats (Lovely et al., 1993; Lyskov et al., 1996; Thomas et al., 1986; Welker et al., 1983; Zhadin et al., 1999), effects that have in part been explained in terms of changes in the glutamate receptor *N*-methyl-D-aspartate (Flohr, 2000; Frilot et al., 2014). A variety of other reports (Cvetkovic and Cosic, 2009; Vorobyov et al., 1997, 1998, 2010) have linked weak ELF magnetic field exposure to changes in the EEG, to electrical activity in the brain (Marino et al., 2004) and to neuroendocrine receptors (Janac et al., 2009). One critically important addition to this body of research (Zhadin et al., 1998) established that the conductivity of glutamic acid in solution increases sharply at remarkably small magnetic field levels (~ 40 nT) when these fields are applied at ion cyclotron resonance field combinations, a result independently replicated in three other laboratories (Alberto et al., 2008; Comisso et al., 2006; Pazur, 2004).

Not only do weak ELF magnetic fields influence neural response, but in view of the very small intensities involved, it is reasonable to expect that magnetic fields of like frequencies and intensities are being endogenously generated in connection with neural function. It is already well-documented using magnetoencephalography (MEG) that the brain generates low-frequency magnetic fields in the range 50–500 fT, mainly due to evoked responses (Hamalainen et al., 1993). It is also known that magnetic intensities well in excess of this range (e.g. α -rhythm, ocular activity) are generated by the nervous system, requiring special pains to filter out such signals to ensure useful MEG data. This magnetic noise that is suppressed in MEG includes nanoTesla intensities. For example, Xu (2012) has estimated that the maximum magnetic intensity generated by the heart is about 12 nT. Therefore, we find ELF neuromagnetic fields at levels that can be both generated and detected by the brain. It follows that such fields must be considered in any discussions concerning EM consciousness.

Sources of environmental ELF fields

We are reasonably certain of the robust effects of weak, non-thermal, ELF magnetic fields at all levels of biological systems, including humans. One of the earliest correlations was to childhood leukemia (Wertheimer and Leeper, 1979). A growing data base relates exposure to

such fields to oxidative stress (Consales et al., 2013; Simko, 2007) and neurodegenerative problems (Jelenkovic et al., 2006; Lai and Singh, 2004; Sobel and Davanipour, 1996). In general, human beings experience a variety of physiological and medical effects that can be traced to both geophysical and electric power sources. Among these varied geophysical sources one finds Schumann resonances (Fullerkrug, 2005; Galejs, 1965), diurnal geomagnetic rhythms (Chapman, 1918; Liboff, 2014a), Pc1 magnetospheric oscillations (pearls) (Guglielmi and Kangas, 2007; Roldugin et al., 2013; Rusov et al., 2012) and, most notably, solar storm activity (Liboff, 2014b). The daily swing in the geomagnetic intensity is approximately 20–50 nT (Liboff, 2014a), but deviations can be up to ten times greater during periods of increased solar activity. The constant stream of charged particles emanating from the sun, even in the absence of solar storms, can result in ultralow frequency oscillations in the geomagnetic field, with the largest frequency band (Pc1) occurring between 0.2 and 5 Hz, resulting in an intensity swing of approximately 0.1–0.2 nT (Belyaev et al., 2003), with occasional short bursts on the order of 100 nT. The physics underlying these magnetospheric oscillations is still largely unresolved (Kepko and Spence, 2003). Although one report (Kleimenova et al., 2007) makes the claim that these oscillations represent a potential health problem, the data in this report can also be explained as due to solar storm activity.

Schumann resonances, waves that circumnavigate the globe, are frequency-specific ELF signals that appear naturally in the EM environment, but are only marginally related to solar activity. They arise because electric discharges associated with lightning launch EM waves into the spatial gap between the two conducting sheets defined by the ground and the ionosphere. Two specific, nearly constant distances conspire to create these resonances, the spacing of the gap between ground and ionosphere and the circumference of the earth. These result in selective reinforcement of the unique frequencies associated with Schumann resonances, namely the fundamental at 7.83 Hz and successive overtones ranging between 14 and 60 Hz (Fullerkrug, 2005). The intensity of these signals is in the pT range, somewhat lower than that found for Pc1 oscillations. These frequencies are ubiquitous and in the ELF region they have been the basis for a great deal of speculation (Cosic et al., 2006; Mitsutaka et al., 2005; Persinger, 2014). However, no substantive evidence has yet surfaced indicating that humans are sensitive to Schumann ELF signals.

The most prominent effect on humans is related to the increased solar activity connected to the 11-year solar cycle. There is a well-established relationship

between solar storms and medical problems, particularly cardiovascular difficulties and stroke, and increases in suicide and psychiatric hospital admissions (Feigin et al., 2014; Liboff, 2014b). These effects follow the ejection of high-energy plasma from the sun that greatly enhances the intensity and speed of the solar wind. If the path of this enhanced wind intersects the orbital position of the earth, the interaction can perturb the geomagnetic field at the earth's surface, resulting in local increases that can range up to 500 nT.

To add to these ELF sources, we argue that an additional ambient ELF magnetic field burden is likely generated by endogenous EM consciousness mechanisms in nearby humans. Even without knowing the precise configuration of the unified EM consciousness field, we can nevertheless point out that a field of approximately 100 nT internal to the cranium can be reasonably expected to produce intensities in the 1–10 nT range at distances of a few meters from the source. The intensity of this radiation, slightly less than the daily swing in the geomagnetic field, can be placed into a category which is greater than that of the Pc1 and Schumann background but less than the maximum effects due to solar storms. Note that the intensity of these putative signals transmitted by the brain is orders of magnitude less than the thousands of nT that humans are exposed to in electric power environments. Table 1 puts this human contribution in perspective by summarizing the various contributions to our ambient ELF magnetic field burden.

A variety of effects

Living systems appear to be designed to take note of even the smallest deviations from the ambient geomagnetic field, sometimes with relatively severe consequences. Two types of physiological change are associated with weak non-thermal ELF magnetic perturbations: first, those that are related to biological clock function (Gamble et al., 2014) and second those that serve a homeostatic function (Liboff, 2010). At the same time, however, the EM approach to consciousness predicts a partial transmission of the 1–100 nT field

generated by the brain, suggesting external interactions similar to other ELF magnetic perturbations that are linked to a variety of homeostatic and endocrine-related physiological effects. It follows that nearby humans may represent an additional, previously unrecognized source of suitably attenuated weak (1–10 nT) ambient ELF magnetic fields that can result in altered endocrine system signaling.

The magnetically dependent endocrine pathway has been extensively studied. It is linked to two modes of EM sensitivity, both of which involve retinal receptors projecting to the suprachiasmatic nucleus, the concentrated set of cells in the brain that control the distribution of endocrine signals throughout the entire organism. One of these retinal clock modes involves melatonin and the other cryptochrome. Melatonin production is suppressed by light as well as by ELF magnetic fields; it is part of the body's natural cycle that promotes enhanced DNA repair mechanisms during sleep (Reiter et al., 2010). The second retinal photoreceptor, cryptochrome, makes use of the underlying free radical chemistry to sense small changes in magnetic field and is thought to provide the physical basis for geomagnetic navigation in animals (Liedvogel and Mouritsen, 2010).

Rounding out this onboard innate sensitivity to ELF magnetic fields, one also finds a second type of ELF magnetic sensitivity that is manifested in holistic fashion, throughout the body. This provides a means of cellular homeostasis that is functionally dependent on geomagnetic ion cyclotron resonance coupling to various elemental cations (Liboff, 1985, 2006), to polar amino acids (Zhadin et al., 1998), to protein hydrolysis (Novikov and Fesenko, 2001), to stem cell differentiation (Gaetani et al., 2009) and, most recently, to the hydronium ion in water (D'Emilia et al., 2014).

Discussion

Our argument boils down to the following: given that weak ELF magnetic fields are not only capable of affecting the endocrine system in humans, but also that one of these ELF sources is linked to nearby humans, it is plausible that natural selection would have utilized this ubiquitous property to enhance interpersonal interactions for purposes of survival. To explore this further, we have introduced the idea of the magnetic cue, a simple change in one's local magnetic field due to a nearby individual's consciousness field, emphasizing that the recipient brain experiences such cues in an unconscious and non-cognitive manner. Although not consciously recognized, signals like this can be learned, i.e. associated over time with the sender, and even

Table 1. Weak ELF magnetic perturbations in ambient geomagnetic field.

Ambient source	Estimated perturbation (nT)	Comments
Schumann	~0.04–0.08	Omnipresent, 7.83 Hz
Pc1,2,...	~0.1–0.2	Sporadic; bursts to 200 nT
Human	~1–10	Distance dependent
Diurnal	20–50	Masked during solar storms
Solar storm	10–500	Maximized every 11 years
Electric power	1000–10,000	50, 60 Hz sources

incorporated into Pavlovian-like responses. It goes without saying that this predicted effect may impact current discussions regarding the interaction of non-thermal EM radiation with humans.

ELF responses in humans can be catalogued as one means of coping with changes in our otherwise comfortable environment. Although these changes are usually framed in biochemical terms, in the case of the ELF fields the initiation of the endocrine response is magnetic (Close, 2012) not chemical. As in the chemical case, the physiological responses to ELF magnetic fields need not be deleterious. Just as there are reinforcing aspects to endocrine function, for example, the antioxidant qualities of increased melatonin concentrations, or the beneficial response to increased serotonin, one should also anticipate that ELF ambient magnetic field perturbations derived from human sources may result in positive outcomes, as seen in the clinical applications of ELF magnetic fields (Diebert et al., 1994; Liboff, 2014c; Novikov et al., 2009).

Thus, the possibility exists that ELF effects related to human consciousness might result in a sort of feedback that is not necessarily harmful. That is to say, if an individual is in some way perturbed due to someone else's magnetic proximity, it is quite conceivable that such unconscious neural interaction could influence the relationship between these individuals, for better or for worse. Further, one might find that such interactions can be described as back-and-forth, analogous perhaps to the behavior of coupled oscillators in the laboratory. At least one observer (McDonnell A, 2014) has concluded that there may be an unrecognized physical means of human/human interaction, perhaps magnetic, dubbed "emotional contagion" occurring in crowd activities such as rioting and mass hysteria.

Above and beyond such reflexive personal interactions, it is reasonable to suggest that special consideration be given to interhuman exchanges where there is naturally an extraordinary physical nearness, making magnetic detection more probable. For example, one can anticipate extremely close magnetic ties from mothers to their children in utero or to babies when suckling and even to couples in coitus. This concept illuminates and adds immeasurably to the notion of bonding that is universally associated with strong family ties.

We have previously suggested (Liboff, 2015b) that information related to migration can be transmitted between mother and offspring in egg-bearing species, focusing on that interval of time between fertilization and hatching. Given the notion that something similar may also happen in mammalian systems, it is tempting to speculate that the phenomenon of reproduction in higher

order animals involves much more than merely the anatomical and biochemical details. It may be the case that certain types of information are electromagnetically transferred from mother to child, even prior to birth.

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Declaration of interest

The author reports no conflicts of interest. The author alone is responsible for the content and writing of this article.

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